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DATA FOR THE DETERMINATION OF HUMAN ENTOZOA—II

By HENRY B. WARD

WITH ONE PLATE

Four years ago I contributed an article on this subject for the TRANSACTIONS. That paper dealt with then known facts regarding human parasites as the means for their determination. The latter problem is essentially a microscopical subject and the constant and increasing use of this instrument in clinical work since then has resulted in considerable additions to our knowledge. It is all important for the accurate identification of these forms that precise data be at hand with reference to the individual species. As I pointed out previously, the data in our possession are fragmentary, and at times conflicting and inaccurate, so that such a positive determination is often a matter of considerable difficulty. In this paper I wish to add to the previous article a brief statement regarding the important discoveries of recent years concerning the eggs of human entozoa. It will be noted accordingly that this paper is limited to a consideration of only a single diagnostic feature, the eggs. While it is my intention subsequently to consider other features noted in my earlier paper, yet, without that, the emphasis on this one element would be justified by the paramount importance in fecal examinations of accurate knowledge concerning the ova. There has been much discussion also concerning the meaning of supposed variations in these structures and some have gone so far as to proclaim the unreliability of evidence adduced from them. In the subsequent pages I hope to show that such opinions are due to a misconception of the facts, and that research has been confirming the accuracy of differential diagnosis based upon the character of the ova.

At the outset it is necessary to dwell once more upon the fact that in common with all similar structures, the ova are not absolutely uniform in size. Some modern investigators have attempted to make and publish measurements of these structures so carefully expressed as to extend the values to tenths of a micron. Such accuracy is largely imaginary and is apt to be misleading, for the range of variation between individual specimens, while small, is nevertheless far beyond such insignificant limits. The average size may readily be obtained by taking ten or a dozen normal specimens. Directly in connection with this matter, it is important to call attention to the error which is introduced by the habit of some investigators in reporting as the limits of size the absolute range which can be found among the eggs in any preparation. This is likely to give a false idea concerning the characteristic type of egg in the species under question and is distinctly misleading when the figures are taken up by a subsequent observer as a means of determining the nature of a questionable species. Where the limits are unreasonably large, such an observer is very likely to think that the eggs he has under examination may properly be included in the species in question, when, as a matter of fact, they fall within the limits of abnormal eggs only and do not conform to the measurements of normal ova. In this matter I agree entirely with Looss, who says (1907:149, footnote): There exist, of course, among the immense number of ova in an individual worm always some which are either larger or smaller than the rest, or even evidently misshapen. In my opinion it is of no use to record carefully the measurements of these eggs also. For the description and definition of a species it is much more important to select for measurement those ova which appear to be normal and to present the size and shape typical for the species. It may be added in passing that young worms with few ova in their uteri usually do not afford normally-shaped and normally-sized ova.

Constant differences in size between specimens measured and the measurements given for a species under consideration create a prejudice at once in favor of the view that the two species are distinct. Disregard of this almost axiomatic statement has brought much confusion. More than once in the past, some of the supposed wide variations in size among the eggs of a certain species have been found to be due to the confusion of two or more closely related forms under a single specific name. This matter was emphasized in the previous article; and, in at least one instance, discussed there, eggs which had been assigned to a certain species, but which yet appeared to be radically smaller than the ordinary measurements of ova in that species, have since been shown to belong to a different species. Further mention of this item will be found later under the discussion of *Paragonimus Westermanii.*

The egg of *Schistosoma haematobium* figured in my previous article (Ward, 1903a, pl. IX, fig. 10) appears to have been somewhat exaggerated in size through inadvertence either in copying or reproducing the figure. Accordingly I have deemed it wise to present a new figure of the egg in this species. It will be noted by comparison that the one shown this time is somewhat narrower in proportion and that the embryo fills a larger part of the shell. The latter feature is one which to some extent at least is dependent upon the stage of contraction of the embryo and will vary considerably in different eggs. No other errors in text or figures of the first paper have been called to my attention.

In agreement with the plan followed in the previous article all figures of ova reproduced on the accompanying plates are represented at the uniform magnification of 500 diameters. Much labor has been expended in the effort to secure for each species the best illustration available. In some cases no figures of the egg exist and in order to secure a representation for ready comparison with other species I was forced to make use of geometric lines drawn as ellipses on the dimensions given for the desired ova. While necessary, this method is very undesirable, since few eggs are a mere ellipse. The method disregards entirely the taper towards the poles of the egg, the size and character of the lid when present, the color, thickness, transparency and other features of the shell, and the nature of the contents. All of these items furnish distinctive features of importance in certain cases, and should be more generally and fully recorded.

The egg shells are the only immobile factors in trematode structure; they are also the portions most usually found and most readily used in the clinical diagnosis of infection with helminthes. Evidently, then, more accurate data concerning them will prove of great value to the clinician.

The idea seems to be prevalent that these structures form an unreliable basis for diagnosis on account of the large variation to which they are subject. I am convinced that this is the most serious sort of an error. All my own observations tend to show great uniformity in size under similar conditions. This uniformity is strongly evidenced in the work of Looss among Trematoda. Whole genera, if not sub-families, among the groups which he is handling in admirable fashion, manifest such close agreement in this respect that the general description of the group includes only a narrow range of size among the ova in the entire series of forms within its limits. These data are far more valuable than has yet been clearly appreciated, and the very existence of marked variation in the records of a single form is presumptive evidence that in the absence of errors of observation, two or more species are confused under the single appellation.

The most extensive additions to our knowledge in this field which have been made within the last four years fall under the Trematoda. Consequently, the major portion of this paper is devoted to that group. No important additions along this line have been made to our knowledge of cestodes parasitic in man. Among the nematodes, however, several species have been discovered and some valuable data can also be presented with reference to older forms. For general data to be utilized in the differentiation of ova and in the diagnosis of parasites by other structures available for clinical purposes, the reader is referred to the preceding paper (Ward, 1903a).

Of *Cladorchis Watsoni,* which has been found but once, parasitic in a negro of German West Africa, Shipley (1905:7) says that the eggs are encased in a shell and contain many deeply staining yolk-granules. He gives measurements for the egg of 122 μ by 80 μ, but Conyngham records the size as 130 by 75 μ. The egg has not yet been illustrated. Only a single case of parasitism by this species has been recorded as yet, so that its pathological significance is uncertain.

Since the publication of my first paper *Fasciola gigantica,* a form previously confused with *Fasciola hepatica* or at most regarded as a variety of that parasite, has been clearly differentiated as an independent species. One case of its occurrence in the human lung is on record. A second probable case is noted by Musgrave (1907:17) for the Philippine Islands. According to Looss

(1902:783) the eggs of *Fasciola gigantica,* with rare exceptions, vary between 145 and 152 μ in length by 80 μ in breadth. In the same species described by Railliet under the name of *F. angusta* the size of the eggs is given as 145 to 150 μ by 82 to 88 μ.

The eggs of *Fasciolopsis Buskii,* which in my previous paper were described after Odhner and which then had not been delineated, have been studied and illustrated by Loos (1905-6). I reproduce a copy of his figure in the accompanying plate (pl. XXVII, fig. 3). He gives the range of size among the ova as 120 to 130 μ in length and 70 to 80 μ in breadth. While he as well as Odhner note that these eggs are in all respects like those of *Fasciola hepatica,* yet the figure of Looss shows them to taper more toward both poles, to have smaller operculum and a thinner shell than the ova of *F. hepatica.* All of these points are clear on comparison of the figures for the two species. The contents of these ova as they appear in the feces show plainly the single germ cell and mass of yolk cells. Development has not yet begun. Manson (1907:738) says that these ova are closed by a very delicate operculum.

A single specimen of *F. Buskii* was found at the necropsy of a Laskar sailor in Galveston, Texas, by Moore and Terrill (1905). These authors give the average size of the ova as 150 by 75 μ. If the magnification assigned to their microphotographs is correct not even the largest reaches this length and the actual size agrees closely with the measurements of Looss cited above.

Goddard has recently (1907:195) reported a case of this parasite from China; the material was referred to a committee and that part of the report of the Investigation Committee which deals with the eggs reads as follows: Eggs (possibly immature). Size not measured, about a half that of *Ascaris lumb.* Shell, very thin walled. Contents clear, small and granular, well marked nucleus in center. Nearly spherical. No operculum observed.

An error is certainly present here, for the size of these ova would equal only 40 to 45 μ by 25 to 30 μ on the basis they give in their estimate. This is far too small for *Fasciolopsis Buskii.* If one infers that the proportions relative to *Ascaris lumbricoides* are by accident reversed in their statement these ova would approximate 130 to 150 μ by 100 to 116 μ and this again fails to agree with the species *F. Buskii* to which they assign these specimens. In fact, the designation "nearly spherical" which they use to characterize the ova can not by any means be applied to the figure which Looss gives of ova in *F. Buskii.* Renewed investigations alone can tell whether the authors are in error as regards their measurements and descriptions or with respect to their identification of the species.

Fasciolopsis Rathouisi was originally described by Poirier in 1887 and since that time no case of its occurrence has been recorded before the present year. Many authors, including Leuckart, who examined one of the original specimens, have considered it identical with *F. Buskii;* but in common with others I have constantly maintained its specific integrity, although in a recent paper (Ward, 1903:867) assigning it to the genus *Fasciolopsis,* originally created for *F. Buskii.*

In the paper just cited Goddard (1907:195) has recorded one case of simple infection supposedly with this species and one case of mixed infection with it and *F. Buskii.* The original description of Poirier is inaccessible to me; according to various authors it states that the eggs are ovoid, measure 150 by 80 μ, and show great similarity to those of *Fasciola hepatica.* The account of Goddard is as follows: The eggs of the *D. rath.* are about two-fifths of the microscopic field under a one-sixth-inch objection and one-inch ocular, have a thin shell and appear to possess a hyaline body moderately well filled with coarse granules of a greenish yellow tint [? in fresh feces]. These eggs were present in both cases reported [one was a case of mixed infection with *F. Buskii.*]

The report of the Investigation Committee to whom these specimens were submitted is given in the same paper (Goddard 1907: 198). The description of the ova reads thus: Egg, oval, size not measured, about one-third larger than *Asc. lumbric.* Thin walled and smooth with very small operculum. Contents appear to consist of large granules.

From this account the size of the ova may be estimated as approximately 100-115 μ by 65-75 μ. Such an ovum would be very much smaller than that described by Poirer for his *Distomum Rathouisi.* The Investigation Committee notes in its report some doubt as to the correctness of the identification, and the doubt is emphasized by this discrepancy in the size of the ova. Further study of these forms is needed to establish their true character.

In the previous paper (Ward, 1903a:118) I called attention to the great discrepancies in published records regarding the ova of *Paragonimus Westermanii,* and put together there the measurements of various authors in an outline sketch (pl. VIII, fig. 1). In the text attention was especially called to the smallest measurements, namely, those recorded by Yamagiwa and the suggestion made that an error had been made or another species was concerned. Since then the discovery of *Schistosoma japonicum* has demonstrated the truth of the latter alternative and the cases of Yamagiwa, who gave measurements of ova from the brain and lung, are now believed to concern this new species. Even after the elimination of these and of the earlier, probably incorrect records of Baelz, there still remain marked differences between various records. These differences are not reconciled by more recent investigations, but on the contrary rather emphasized, as the following record of such investigations will show.

The only case of parasitic hemoptysis, due to infection with *Paragonimus Westermanii,* yet observed, in man in this country (Mackenzie, 1904:1134) was diagnosed by means of microscopic examination and demonstration of the ova in the sputum of the patient, a Japanese fisherman, working on the Columbia River. Thirty-one ova were measured and found to vary from 85.5 μ to 99.7 μ in length and from 48 to 69 μ in breadth, with an average size of 91.3 μ by 55.2 μ. The measurements given by Katsurada (1900) vary from 87.5 μ to 102.5 μ in length by 52.5 μ to 66.3 μ in breadth, with average values of 93.5 by 57 μ. These two series agree very closely with each other and with records of Baelz, Leuckart and Manson. It should be noted that all were made on parasites from hosts of the same nationality and undoubtedly represent the same species of parasite.

Of importance is the observation of Looss on this species. He says (1905:283, note 1): The size of the ova in *Paragonimus Westermanii* is given rather differently by previous authors: 80 to 100 μ in length by 50 to 70 μ in thickness. Since I have found them in mature intact worms only 77 to 81 μ long and 43 to 50 μ thick, the larger measurements cited above speak for confusion with other eggs. The eggs of *P. Westermanii* possess, moreover, a relatively thick yellowish to reddish-brown, plainly operculate shell and at the time of elimination from the body of the host always contain only a simple germ cell surrounded by yolk cells.

These measurements of Looss do not agree with any others from man, though nearest those of Musgrave (1907) and markedly different from those of Katsurda and Mackenzie. The source of the material used by Looss is not given. The accuracy of Katsurada's work can not be doubted and his material came from the classic field of infection with the Asiatic lung distome; hence the eggs of this species were before him when preparing his record of the size and character of the ova. Nevertheless, the average measurements of Loos agree exceedingly closely with those of Kerbert, based on the original material of *P. Westermanii* obtained from the tiger.

Paragonimus Westermanii has been most carefully studied by Musgrave (1907) in the Philippines. He says of the ova: The eggs are oval in shape and vary in color from a reddish-brown to light-yellow, the color depending somewhat upon the stage of their development and the source from which they are obtained and perhaps, also, upon other conditions which are not fully understood. Again, their size varies considerably, and a glance at Table No. 3 will show the marked differences in the measurement given by some of the principal observers. I have carefully measured several specimens with the Zeiss photomicrographic apparatus, with the following results:

Length, 0.0062 to 0.0098; average, 0.0074.

Breadth, 0.0045 to 0.0063; average, 0.0057.*

Eggs in sections of tissues and those preserved in any other manner contract somewhat and these are not considered in the measurements given above. A well-marked operculum is probably present in all mature specimens, but in many instances this is indistinct and at times it can not be made out at all. This operculum has quite a distinctive appearance, which is noticeably different from that of some of the other fluke eggs. The operculum in the ova under consideration appears to fit into an opening very much in the manner of a cork into a bottle, whereas in some of the other trematodes, particularly *Opisthorchis,* the opercula appear to be placed over openings more in the fashion of a cap.

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*These figures are evidently far too small and I conclude that the decimal point is incorrectly placed and they should read 0.062 mm., etc., or 62 μ, etc.

The ovic cell in many specimens is quite distinct, and several yolk cells are then also present, but in others, even if they are taken from the same abscess, no such structure can be made out.

The record of Musgrave agrees in breadth of the ova exactly with the determination by Katsurada (1900:508). But the latter records the average length of eggs as 93.5 μ as against Musgrave's average measurement of the length at 74 μ. This adds another difficulty to a series of measurements already manifesting greater variations than are known to occur among the eggs of any other trematode. I have been for some time of the opinion that the American form reported from the cat, dog and hog, constitutes a different species from that found in man in the East. Yet the adoption of this view does not clear up the question satisfactorily. Either one must acknowledge an unusual variation in size among the ova of this species, or an exceptional number of errors in observing or recording their measurements, or be forced to conclude that several species of closely similar appearance and structure have been bunched under the one name. Musgrave's cases apparently all concern natives of the Philippine Islands.

These measurements and those given in my previous paper may be most readily compared in the form of a table which I append here.

		—RANGE OF SIZE—		AVERAGE		
AUTHOR	DATE	LENGTH	BREADTH	SIZE	HOST	COUNTRY
Kerbert	1881			80 x45	Tiger	Holland
Leuckart	1889	80 -100	- 56	90* x56	Man	Japan
Ward	1894	96 -118	48 -55	102 x53	Cat	U. S. A.
Stiles and Hassall	1900	78 - 96	48 -60	85.6x53.2	Hog	U. S. A.
Katsurada	1900	87.5-102.5	52.5-66.3	93.5x57	Man	Japan
Mackenzie	1904	85.5- 99.7	48 -69	91.3x55.2	Man (Jap.)	U. S. A.
Looss	1905	77 - 81	43 -50	79* x46*	Man?	?
Manson	1907	80 -100	40 -60	?90* x50*	Man	?
Musgrave	1907	62 - 98	45 -63	74 x57	Man	Philippines

All measurements in microns.

* Estimated.

The entire matter may be summed up in the following paragraph, in which regard is had not only to the ova, but to other structural elements as well. After extended study I am convinced that the American form which I described originally and identified as *Paragonimus Westermanii* is undoubtedly a distinct though close related species to which I now wish to give the name of *Paragonimus Kellicotti.* It is well known through the original description and the subsequent complete accounts of Stiles; yet it is my intention to publish shortly a study of this species, giving more complete justification of its specific distinctness from the Japanese form.

I am endeavoring to secure material from the Philippines also to compare with each of these two forms as well as with material from the tiger. The great similarity in the various measurements of Japanese material made by different observers at widely separated times and places, namely: Baelz, Leuckart, Manson, Katsurada, and Mackenzie, whose averages vary only a few microns, indicate that this form may be after all a distinct species from Kerbert's tiger parasite with which the Japanese measurements do not agree. The Japanese form will, however, not need a new name, but probably will go back properly to take one of the earlier names used by investigators of the human parasite in Japan. To determine correctly the facts in this case demands most careful study and hasty action will only add to the confusion already existing.

In a recent most valuable paper, Looss (1907) has differentiated the old species *Opisthorchis sinensis* into two distinct forms, *Clonorchis sinensis,* the *Distomum innocuum* of Baelz, and *Clonorchis endemicus,* the *Distomum endemicum* of Baelz; the latter practically takes the place of the true *Clon. sinensis* in the literature published after 1883 and is at present the one usually described in the text books, etc., as *"Opisthorchis sinensis."*

Regarding the ova of *Clonorchis sinensis* Looss says (1907: 149): The average dimensions of the eggs are 0.029 mm. in length and 0.016 mm. in width; the limits of the former being 0.026 and 0.03 mm., and of the latter 0.015 and 0.017 mm. In many specimens of the species the eggs show a distinct narrowing towards the anterior extremity, and their rather high lid is marked off by a sharply projecting brim. I have, however, also seen specimens in whose ova these peculiarities were but little pronounced.

The description of the ova of *Clonorchis endemicus* given by Looss (1907:151) is as follows: The eggs have about the same length as those of the preceding species (0.026 mm.), but their width is decidedly somewhat smaller, amounting on an average to 0.015 mm., with the lower limit at 0.013, the upper at 0.016 mm. The narrowing towards the anterior end is in the main not so marked and the margin of the rather flat lid not so sharply projecting as in *Clon. sinensis;* but these differences are on the whole very slight and not recognizable in every specimen.

I have reproduced here (pl. XXVII, figs. 1 and 2) figures of the two species given by Looss to illustrate his descriptions. Evidently the exact determination of the species on the basis of the ova alone will be a difficult matter even under favorable conditions. It should be noted that Looss does not find the blunt process at the pole of the egg opposite the lid which was illustrated after both Ijima and Katsurada in my previous paper (Ward, 1903a:137, pl. 8, fig. 7).

Of the greatest importance for the proper recognition and accurate identification and differentiation of the human parasites are careful studies of the ova under different conditions and at various phases of development. A most valuable work of this type has recently been published by Saito (1906:133) on *"Distomum spathulatum."* The species on which he worked was evidently the Japanese form, which Looss more recently has designated *Clonorchis endemicus.* Saito presents a brief record of the data regarding these eggs as given by others, especially the Japanese investigators, and then states his own results, from which the following is taken: At its tapering end the egg shell is provided with a helmet-shaped lid; the line of union is marked by a projecting rim. The embryonic development occurs in the uterus and eggs taken from its terminal coils contain completely developed embryos. Fresh eggs in the uterine coils occasionally open of themselves, naturally much more easily those from feces. The so-called "Stäbchenkörper," which up to the present time has been regarded as a yolk remnant, must be considered as a part of the embryo.

The appearance of the egg at different stages is both described and figured, as also the appearance and structure of the embryo. Unfortunately the author does not give a series of careful measurements and his figures are not accompanied by a record of the exact magnifications. It is worthy of note that he represents fresh ova both with the short, blunt process at the posterior end and without this structure.

During the past few years our knowledge of the schistosomes, or blood flukes of man, has been greatly extended. To the well known Egyptian blood-fluke, *Schistosoma haematobium,* two new species have been added which also occur in the human host. Of the original species, *S. haematobium,* a recent valuable publication by Looss (1905b:101) records the following important data: When in the uterus of the female worm and immediately after deposition these ova measure on the average 80 by 30 μ and contain an unsegmented egg cell surrounded by a mass of yolk cells. During their stay in the tissues where cleavage and development of the embryo takes place, the eggs increase so markedly in size that at the close of this period they usually measure 110 to 120 μ in length by 46 to 50 μ in breadth. The thin, yellowish shell carries at one end a short pointed spine of variable length. Among these one finds often another form which is characterized by a larger, lateral spine.

Regarding the latter type of ovum, which is said to occur in feces only, more will be said later on in this paper. Certain it is that among eggs taken from the urine there is found more than one type which departs noticeably from the normal average form of the egg in *S. haematobium.* The form with a lateral spine has been taken as the basis of a new species, *S. Mansoni,* which is considered below; but the same method can hardly be followed in the case even of all recorded variations which are of an extreme type. Prominent among such let me call attention to the observations of Christophers and Stephens (1905:259). In an important note on a peculiar schistosome egg, these authors record that these eggs were met with in the urine of a native of Madras suffering from haematuria. The egg differed from that of the *Schistosoma haematobium,* inasmuch as it was of a long spindle shape, and from the thick end of the egg a long, snout-like process projected. The egg measured 205.2 by 53.2 μ, being therefore much longer than other schistosome eggs. In the urine there occurred also eggs indistinguishable from those of *S. haematobium,* so that the *significance* of the spindle-shaped variety was uncertain.

When one considers that the ova observed in this case are only slightly broader than the normal egg and yet 75 to 80 per cent longer, it will be acknowledged that such a difference can not possibly be accounted for by any normal variations in size. What were the abnormal conditions producing such ova or whether a new species is concerned, must await further investigations. The possibility of a mixed infection with two species of *Schistosoma* can not be dismissed without consideration. Further observations in the same region would throw light upon the question; but so long as only one case is on record, these ova must be considered as merely abnormal variations of a radical type.

A new species of *Schistosoma,* designated the Asiatic bloodfluke *(S. japonicum)* was first described and named by Katsurada (1904). His account of the eggs of this parasite may be abstracted as follows: Eggs from human feces; usually oval or elliptical, thin-shelled, yellow or light brownish yellow, without lid, and without spine. In fresh material they measure 75 to 90 μ by 52.5 to 72.5 μ, with an average size of 83.5 μ by 62.5 μ. The egg from feces contains a well developed, ciliated embryo. Ova in human liver tissue measured, on the average of 25 specimens, 72 by 49 μ, being thus somewhat smaller than in feces, owing to the influence of the preservative.*In the liver of a cat the ova measured 64 μ, or in a sec-

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*Compare in this connection the more probable explanation of Looss, cited above (p. 188) for the increase in size of the ova of *S. haematobium* between the time of deposit by the female worm and of exit from the tissues of the host. So large a contraction as indicated by Katsurada's figures, *i. e.,* one-sixth or more, could not in my opinion be brought about by the action of preserving fluids. I have measured ova in several species while fresh and after preservation in various fluids and have never been able to demonstrate any positive constant difference. Irregular shrinkage does of course occur, so that many ova can not be measured at all, but uniform contraction appears to be confined at least within narrow limits. It is important that this matter be re-examined to determine whether the changes in size from liver to feces are constant. Katsurada indicates that the transition is accompanied by the growth of the embryo which is not formed in eggs from the liver, but present in eggs taken from feces. I see no reason why eggs in intestinal tissue or in feces should contract less than those in liver tissue under methods of preservation probably similar. It is clear, however, how the growth of an embryo might gradually enlarge the shell.

ond host 70 by 74 μ, and in the intestinal wall 67 by 50 μ. In the uterus of the female worm the average length of a series of ova was 58.4 μ, the average breadth 42.5 μ; thus the uterine egg is the smallest of those described. The hosts were all native to Japan.

Almost simultaneously with Katsurada, Catto described the same species. He gives the measurements of the ova as 60 to 90 μ by 30 to 50 μ, with an average of 70 by 40 μ. He speaks of the shell as stout, but otherwise agrees with the description cited above. The host came from China.

Recently a case of this parasite has been reported from the Philippine Islands by Woolley. In the description of the parasite this author says (1906: 87): The following comparative measurements of the ova were furnished to me by Dr. Shiga, after he had examined my specimens and compared them with those of Fujinami and Manson:

	Manson	Fujinami	Woolley
Length	72.8 μ	66.2 μ	62.4 μ
Breadth	48	43.6	43.6

This case was in a native Filipino who had never been out of the islands.

In general one may say that the eggs of *Schistosoma japonicum* are smaller than those of *S. haematobium,* have blunter ends and no spines. There are also considerable differences between the measurements given by the various observers, some of which are explained on the basis of Katsurada's observations concerning the stage of development of the ova. These observations are cited above.

The early history of Catto's material is worthy of note as indicating the difficulties at times in the way of an accurate microscopic diagnosis. At a necropsy certain lesions were observed and tissue preserved and later sectioned from the liver, mesenteric lymph glands and intestine. These sections were examined by at least three pathologists and showed numerous small oval bodies having a smooth, stout capsule. Opinions differed as to their character, but the case was originally published as one of coccidiosis in man. This is not the first case in which trematode eggs have been diagnosed and published as coccidia (Ward, 1903a:115). Specimens were also shown at the Medical Research Club, London, but no definite conclusion was reached regarding the nature of the oval bodies. An eminent German authority to whom pieces of the tissues were sent stated "that the oval bodies were neither coccidia nor the eggs of a trematode, but those of a nematode of unrecognizable species, etc."

At the British Medical Association in July, 1904, the case was reported to the section on tropical diseases, and the abstract of the proceedings (J. Trop. Med., Aug. 15, 1904; London Lancet, Aug. 27, 1904) includes but one interpretation of these structures, *viz.*, as eggs of an oviparous nematode new to pathology. Stiles (1905) errs in stating that the author claimed he had a new species of trematode for man, apparently also in giving the date of this publication as September 7, 1904.

I was at the International Zoological Congress at Berne, Switzerland, in August, 1904, when Sir Patrick Manson sent some of Catto's slides to Professor Blanchard, who at once called into consultation Looss, Monticelli, Stiles, and myself. The view that these questionable bodies were nematode eggs was reported to us and promptly discarded in favor of the opinion advanced first by Looss that they were the ova of a new blood-fluke, evidently related to *S. haematobium,* but readily distinguishable from that species. Later in the same summer both Stiles and I had the opportunity of examining Catto's material in London and of confirming the preliminary diagnosis. By most careful work Catto dissected adult worms out from the infected tissues and published a full account of the case and its parasite as Cragg's Prize Essay for 1904 from the London School of Tropical Medicine.

The eggs of this species are by no means new in pathology. Many cases from Japan in which eggs have been reported previously in nodules from the omentum, mesentery, peritoneum, rectum, and from a cirrhotic liver, are interpreted by Looss (1905:282) as properly belonging to this new *Schistosoma japonicum.* Katsurada includes in the same category the cases of Yamagiwa in which eggs were found in the cortex cerebri and were regarded as the cause of Jacksonian epilepsy. I pointed out in my previous paper (1903a: 118) that they could hardly belong to the species *Paragonimus Westermanii,* to which the Japanese author had assigned them, and suggested that if the records were correct, a new species was probably concerned. The drawing I gave agrees well with the measurements assigned to ova of *S. japonicum* by both Catto and Katsurada. Looss very justly calls attention to the necessity of distinguishing sharply between the two species in cases where ova occur in nodules in human tissues and suggests that this will not be difficult in view of the different structure of the shell and of its contents. The data for the ova of *Paragonimus* are given above.

Booth (1907:201) is the first to give a detailed descrption of the eggs and embryos of *S. japonicum* from fresh material. At the Hankow (China) Hospital, he examined ova from fresh feces. They were a little larger than those of *Ascaris lumbricoides* in the same material, oval in shape, transparent, thick-shelled, and occupied by a well developed embryo. The shell had neither spine nor operculum. The embryo was oval and smaller than the shell, while within the shell on each side of the embryo lay two oval yolk bodies. The embryonic cilia were in motion and two hours' incubation of feces at 37° C. resulted in finding many empty shells. In every case the shell ruptured at the side and the last part to leave was the anterior end of the embryo.

Very recently Sambon has described a third species of *Schistosoma* from man and bases the description entirely on the ova. He lists for them the following characteristic features: the ova are large, with rounded ends and a lateral spine, which is heavy, prominent and sharply pointed. According to Holcomb, who has been able to examine a large number of these eggs, they measure from 112 to 162 μ in long diameter, and from 60 to 70 μ in breadth. So far as known, these lateral-spined ova are voided exclusively with the feces and endemic haematuria is totally unknown in the West Indies where, according to the latest reports, this form is extensively prevalent. Sir Patrick Manson discovered such ova in 1903 and suggested their specificity. Similar ova had indeed been seen before and according to Bilharz and Mantey they occur singly in isolated cases.

On the basis of personal experience Looss (1905b:102) rejects this view regarding them as abnormal structures which with regularity are produced at the outset of sexual activity and suggests that possibly mature but unimpregnated females produce such ova. He represents the mode of formation of such an egg and also illustrates a transition form between the normal terminal-spined egg and the lateral-spined form which he regards as abnormal. I reproduce here (fig. 7) from his work a lateral-spined ovum to show the type he has in mind. He calls especial attention to the extreme rarity of this type, which is by far most frequently found in the liver where they not rarely occur unmixed with normal eggs. The figure of such an ovum copied from Looss seems to confirm his view since in the place of the usual well formed embryo this egg contains a granular mass indefinite in character save for numerous oil (?) globules (fig. 7). Such an appearance indicates a disintegrating mass, and accords with the theory that the ovum was not fertilized. On the other hand, the constant differences in size, place of deposition and geographical distribution point very strongly to the specific independence of this form. It may be that in reality there are two forms: an abnormal variety of *S. haematobium,* rarely found, which contains a degenerating mass of cellular debris and a normal, lateral-spined ovum, belonging to an independent species. The admission of Looss that the lateral-spined ova are by far most frequent in the liver accords with their attainment of the intestinal wall and ultimate escape from the body by the feces rather than by the urine as in the case of *S. haematobium.* Most careful study should be devoted to the cases in which lateral-spined ova are found. In case the somewhat larger size, noted by Sambon, is confirmed on further measurements the specific identity of the worm will be established even before the adult is seen.

The lateral-spined ovum, copied after Looss, is much smaller than the minimum figures for the ova from the West Indies, which Sambon regards as belonging to *S. Mansoni.* This difference in size as well as a distinct variation in form are evident from a comparison of Looss' egg (fig. 7) with an outline giving the dimensions assigned to ova of *S. Mansoni* by Sambon. This lends color to the view that the type which Looss has illustrated is not the true *S. Mansoni* but some abnormal form. I incline to the opinion that the view of Manson, worked out more recently by Sambon, will prove to be the correct one.

Since writing the above discussion, I have secured a copy of a paper by Holcomb (1907) which gives a most exhaustive discussion of the subject and leaves no doubt of the specific validity of *S. Mansoni.* He shows that there is throughout the West Indies an extensive schistosome infection which is characterized by lateral-spined ova voided in the feces of the host. This same form is also most frequent in Central Africa, while the variety producing terminal-spined ova exists in its purest form in Cape Colony and a more or less mixed infection occurs in Egypt. Holcomb believes that the females described by Looss and others were possibly not abnormal types, since such an ootype as described by Fritsch must have produced invariably the lateral spine. The mere fact that the spine was lateral would hardly account for the fact that these females usually selected the intestinal tract in which to deposit their eggs, nor would it explain why this particular worm should find the conditions to perpetuate its type when transplanted to the West Indies. The West Indian infection proves that they are not the eggs of unfertilized females, and some of his cases, which were under observation for one year or more, show only too well that the persistence of this type of egg can not be attributed merely to young females. In the light of these facts, Holcomb believes that these other observers have described not abnormal forms, but really the essential difference between the female *Schistosoma haematobium* and the *Schistosoma Mansoni.*

It is not impossible that the *Schistosoma Mansoni* of the West Indies is a lineal descendant of the parasite now known as existing in Central Africa and that it was carried to these localities by the traffic in slaves.

This somewhat lengthy discussion is justified by the confusion which has existed and the very recent date of the elucidation which the subject has received. In the light of Holcomb's careful report there remains only the single doubt created by the great dissimilarity between his figure of the ovum of *S. Mansoni* (fig. 8) and that for the so-called abnormal ovum of *S. haematobium,* according to Looss (fig. 7). The exactness of the latter observer suggests again the view I advanced above that the type he illustrates was after all ***not** S. Mansoni.* It is impossible to believe that the same species could have ova varying so greatly as these figured by Looss and by Holcomb.

In his complete and detailed description of the new species, Holcomb (1907:66) says of the eggs that they are found without difficulty in the feces when present.* * * They do not occur in the urine. * * * They are oval in shape and of a pale straw color, and so transparent that the inclosed miracidium is readily made out. My measurements of a number of eggs have shown them from 112 to 162 μ in the long diameter. In breadth they measure from 60 to 70 μ. They are provided with a spine of from 15 to 17 μ in length, and which is sharply pointed. This spine, although I have previously reported it at the juncture of the posterior and middle third of the shell, is, from further measurements, more correctly located at the juncture of the last and third quarter of the egg. The spine is directed backward. When the shell is broken by the miracidium the rent is usually in the direction of the short diameter and curving toward the long diameter as it approaches it.

Lining the inside of the shell is the vitelline membrane. This membrane is usually made out without much difficulty and is clearest in the pole of the egg, at which the cephalic extremity of the miracidium presents. Here there is usually a clear space between the membrane and the shell.

Within the vitelline membrane is inclosed a miracidium—a brownish membrane of granules in a high state of molecular vibration—and several clear, slightly opalescent bodies. The brownish membrane consists of a thin layer of granules which surrounds the whole miracidium. They are usually found in a high state of molecular activity in the matured eggs. The opalescent bodies are more frequently two in number, but I have found as many as five. They are of a somewhat hyaline substance and though of oblong dimensions, usually saddle the miracidium so that the side view presents, giving them the appearance of oval bodies jammed between the miracidium and the shell. These bodies appear to be of the nature of food for the embryo, as in cases where the feces have been mixed with sand and kept for one or more days they are usually absent. The miracidium can be readily seen through the shell.

No important data regarding the ova of Cestoda have been secured since the publication of my previous paper. Moreover, for the clinical determination of tapeworms the eggs are of subordinate value. The alimentary canal being the seat of adult cestodes in man and a diagnosis being regularly made by the discovery of proglottides in the feces, the problem is much simpler than with trematodes or nematodes.

Among the round worms or nematodes half of the species or more are viviparous, and consequently do not enter into consideration here. Among the others there are a few species concerning which important new data are recorded.

On the basis of a careful study of an extensive series of specimens and of type material, Looss (1905a) has been able to distinguish three separate species among the nematodes formerly diagnosed as *Strongylus subtilis* and to establish the identity of the true species *subtilis* with that earlier designated as *instabilis* by Railliet. The forms belong properly to a distinct generic group named *Trichostrongylus* by Looss. Of the three species which occur in man, *Tr. instabilis* is the most common; it is also the only one as yet found in the human host outside of Egypt, having been reported from Japan by Ijima. In Egypt Looss records that he has found the parasite frequently, but always in insignificant numbers, not exceeding 30 to 40 individuals in a single host. Its infrequence, small size, and lack of hooks, bristles, and buccal armature, indicate that its presence is not accompanied by mechanical disturbance of the alimentary lining and Looss is unable to detect any pathological significance in its parasitism. In Japan, however, it occurs occasionally in man in great numbers and under these circumstances may be of pathological importance.

The ova are thin-shelled, colorless and in form and appearance much like those of the European hookworm (*Ancylostoma duodenale*), so that on superficial examination of fecal material from man it may be confused with them. In the uterus of the young female parasite they have not begun development, but in older worms or when taken from feces they show 8 to 32 cleavage cells already formed. The egg shell measures 73 μ to 76 μ, or rarely 80 μ in length by 40 μ to 43 μ in breadth, being thus much larger than those of the European hookworm, which measure 56 μ to 61 μ in length by 34 μ to 38 μ in breadth, and somewhat larger than those of the American hookworm (*Necator americanus*), which are 64 μ to 72 μ long by 36 μ thick. According to Looss, the latter eggs are especially characterized by a marked tapering toward one pole, a feature not found in either of the other species.

In *Trichostrongylus probolurus,* a closely related species, the eggs are similar in appearance and nearly like in size, measuring 76 μ to 80 μ in length by 43 μ to 46 μ in breadth. This species has been reported hitherto only in Egypt as a human parasite and even there it appears to be infrequent in the human host.

Still a third species, *Tr. vitrinus* is also recorded as a rare human parasite in Egypt. Its eggs are somewhat larger, measuring 84 to 90 μ in length by 46 to 50 μ in breadth. The eggs of these three species are so much alike that on the basis of present knowledge nothing more accurate than a diagnosis of the genus could probably be made from an examination of the fecal matter containing them.

A new sclerostomid, parasitic in man, has been described by Railliet and Henry (1905) as *Triodontophorus deminutus.* It was collected in Africa at the autopsy of a native. The ova are ellipsoidal; measured through the body wall, they vary from 60 to 65 μ in length and from 38 to 40 μ in breadth. The same authors have also described (Railliet and Henry, 1905a) another new sclerostomid, *Oesophagostoma Brumpti,* from a negro in Africa, but in this case no eggs were found in the worm.

Only a single record is at hand concerning *Physaloptera caucasica.* Of the ova of this species its describer, von Linstow, says that they are very thick-shelled and measure 57 μ long by 39 μ broad. This species was noted in my earlier paper as uncertain in importance and data regarding its eggs were not cited. On account of its possible recurrence in the Orient, if at all, these facts are given briefly here to make them available for comparison.

A single record concerns a new nematode from man, reported from Texas and described as *Ascaris texana.* It appeared doubtful that the form should retain its position in this genus, and this view is strengthened by the re-examination of the material by Stiles. The question must remain undecided until the male is found and described. According to Smith and Goeth (1904) the ova of this parasite were numerous in both specimens. The description concerns, of course, the uterine egg which is reported as well advanced in cleavage, colorless, provided with a thick wall, without visible external marking or envelope as met in the eggs of certain of the Ascarides. The ova measure 60 by 40 μ, with a variation of 4 to 5 μ in different specimens measured. The interior appeared granular, no nuclei being appreciable in the specimens at hand. Two drawings of ova are given; they do not agree well in form, appearance or internal structure. Further data are essential if this species is to be recognized from fecal examinations; meantime, it cannot be averred that the species is more than purely casual as a human parasite.

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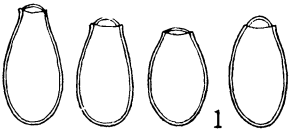
PLATE XXVII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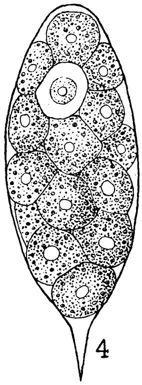
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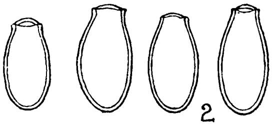
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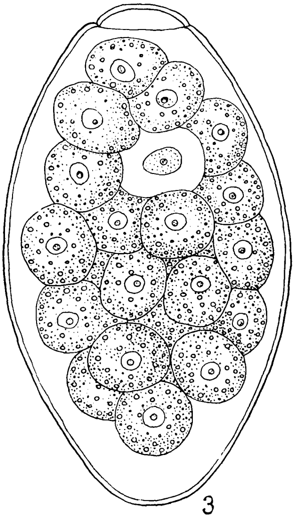
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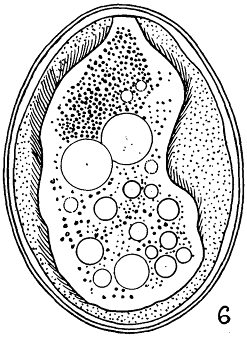
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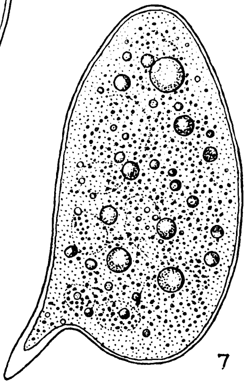
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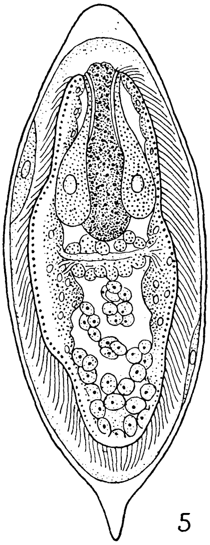
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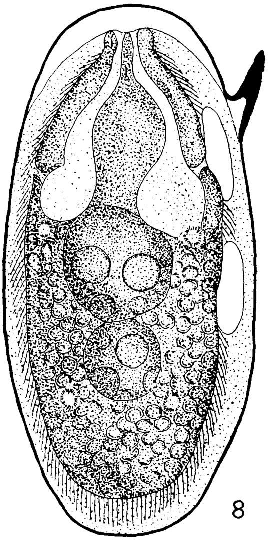
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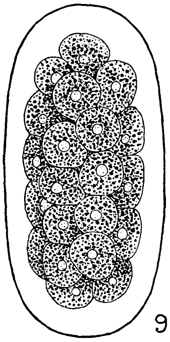
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EXPLANATION OF PLATE XXVII

All of the figures have been brought to the same scale in copying and the reproduction has made them of the uniform magnification of 500 diameters. Unless otherwise stated they represent normal and average ova for the species indicated.

FIG. 1. *Clonorchis sinensis*. The chief forms presented by the eggs, each egg taken from a separate specimen of the worm. After Looss, 1907, pl. IX, fig. 7.

FIG. 2. *Clonorchis endemicus*. Eggs figured in the same manner and under exactly the same enlargement as in the preceding drawing so as to allow of comparison. After Looss, 1907, pl. IX, fig. 8.

FIG. 3. *Fasciolopsis Buskii;* egg from uterus of full grown worm. After Looss, 1905, pl. IX, fig. 4.

FIG. 4. *Schistosoma haematobium;* egg from uterus of female worm, occasional only in feces and then generally calcified. After Looss, 1905, pl. IX, fig. 8.

FIG. 5. *Schistosoma haematobium;* normal egg from urine. After Looss, 1905, pl. IX, fig. 7.

FIG. 6. *Schistosoma japonicum;* egg from fresh feces. After Katsurada, 1904, pl. VII, fig. 1.

FIG. 7. *Schistosoma haematobium;* abnormal (?) egg from feces. After Looss, 1905, pl. IX, fig. 9.

FIG. 8. *Schistosoma Mansoni;* showing the lateral-spined egg with the miracidium. The different structures are shown diagramatically. After Holcomb, 1907, p. 66, fig. 3.

FIG. 9. *Trichostrongylus instabilis;* egg from feces. After Looss, 1905, pl. IX, fig. 21.